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Medical Computer Vision: Algorithms for Big Data

International Workshop, MCV 2015
Held in Conjunction with MICCAI 2015
Munich, Germany, October 9, 2015
Revised Selected Papers

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Preface

This book includes articles from the 2015 MICCAI (Medical Image Computing for Computer Assisted Intervention) workshop on Medical Computer Vision (MCV) that was held on October 9, 2015, in Munich, Germany. The workshop followed up on similar events in the past years held in conjunction with MICCAI and CVPR.

The workshop obtained 22 high-quality submissions that were all reviewed by at least three external reviewers. Borderline papers were further reviewed by the organizers to obtain the most objective decisions for the final paper selection. Ten papers (45%) were accepted as oral presentations and another five as posters after the authors responded to all review comments. The review process was double-blind.

In addition to the accepted oral presentations and posters, the workshop had three invited speakers. Volker Tresp, both at Siemens and Ludwig Maximilians University of Munich, Germany, presented large-scale learning in medical applications. This covered aspects of image analysis but also the inclusion of clinical data.

Pascal Fua of EPFL, Switzerland, discussed multi-scale analysis using machine-learning techniques in the delineation of curvilinear structures. Antonio Criminisi presented a comparison of deep learning approaches with random forests and his personal experiences in working with and comparing the two approaches.

The workshop resulted in many lively discussions and showed well the current trends and tendencies in medical computer vision and how the techniques can be used in clinical work and on large data sets.

These proceedings start with a short overview of the topics that were discussed during the workshop and the discussions that took place during the sessions, followed by the one invited and 15 accepted papers of the workshop.

We would like to thank all the reviewers who helped select high-quality papers for the workshop and the authors for submitting and presenting high-quality research, all of which made MICCAI-MCV 2015 a great success. We plan to organize a similar workshop at next year's MICCAI conference in Athens.

December 2015

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Modeling Brain Circuitry over a Wide Range of Scales (Invited Paper)

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Abstract. We briefly review the Computer Vision techniques we have developed at EPFL to automate the analysis of Correlative Light and Electron Microscopy data. They include delineating dendritic arbors from LM imagery, segmenting organelles from EM, and combining the two into a consistent representation.

Keywords: Brain Connectivity · Microscopy · Delineation · Segmentation · Registration

Overview

If we are ever to unravel the mysteries of brain function at its most fundamental level, we will need a precise understanding of how its component neurons connect to each other. Electron Microscopes (EM) can now provide the nanometer resolution that is needed to image synapses, and therefore connections, while Light Microscopes (LM) see at the micrometer resolution required to model the 3D structure of the dendritic network. Since both the topology and the connection strength are integral parts of the brain's wiring diagram, being able to combine these two modalities is critically important.

In fact, these microscopes now routinely produce high-resolution imagery in such large quantities that the bottleneck becomes automated processing and interpretation, which is needed for such data to be exploited to its full potential.

In our work, we have therefore used correlative microscopy image stacks such as those described in Fig. 1 and we have developed approaches to automatically building the dendritic arborescence in LM stacks [5, 6], to segmenting intra-neuronal structures from EM images [1, 4], and to registering the resulting models [3]. Figure 1 depicts some of these results. In all cases, Statistical Machine Learning algorithms are key to obtaining good results. Therefore, our challenge is now to develop Domain Adaptation

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techniques that will allow us to retrain them quickly and without excessive amounts of additional annotated data when new image data is acquired [2]. For additional details on this work, we refer the interested reader to the above mentioned publications.

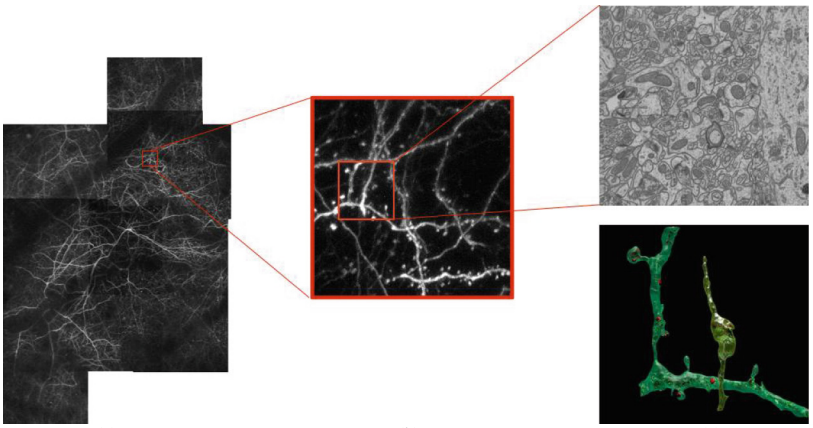

Fig. 1. Correlative Microscopy. (a) Fluorescent neurons in vivo in the adult mouse brain imaged through a cranial window. (b) Image stack at the 1 μm resolution acquired using a 2-photon microscope. (c) Image slice of a sub-volume at the 5 nm resolution above a reconstruction of a neuron, dendrite, and associated organelles.

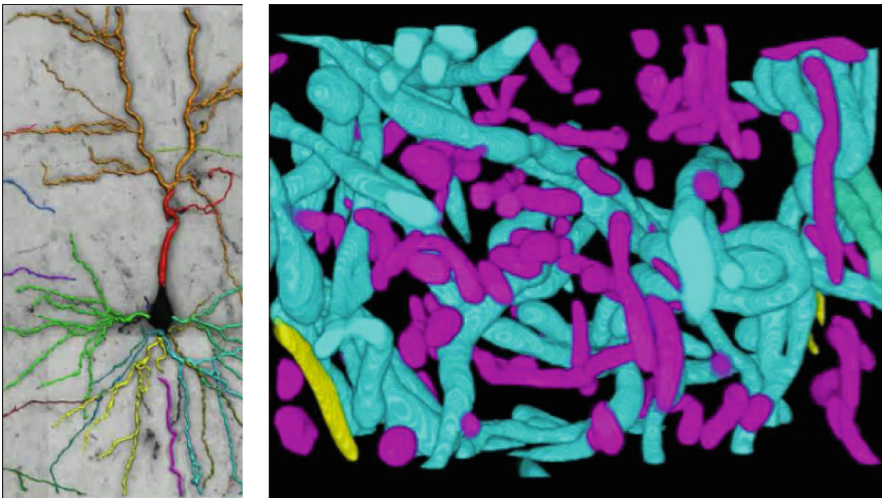

Fig. 2. Automated delineation and segmentation. (a) Dendrites from an LM Stack. (b) Mitochondria from an EM stack. The colors denote those that are either within a dendrite or an axon.

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